Electrostatic Precipitator for Marine Engines

Automatic maintenance mechanism

We have developed a "hole-type" electrostatic precipitator (ESP) to prevent collected particulate matter (PM) from reentering the airstream under high-wind-speed conditions. Figure 1 shows the system structure of the hole-type ESP.

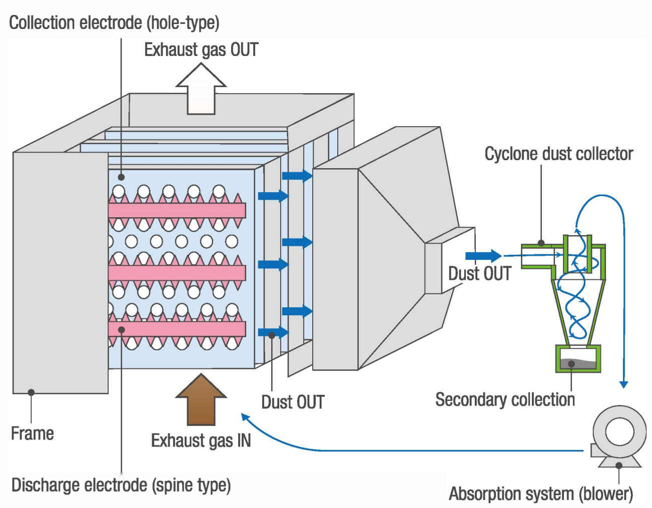

Figure 1. System structure of hole-type ESP. With the collection electrode, the width and number of columns are adjusted according to the flow rate of the exhaust gas.

Accumulation of PM within the hole-type ESP decreases the effective electrode area; thus, dust-collection performance decreases over time. To prevent this accumulation, it is necessary to automatically clean the electrode surface at appropriate intervals to discharge collected PM outside the system. In the system structure in Figure 1, the PM that has accumulated within the collection space is suctioned off and recovered automatically to maintain the desired dust-collecting performance.

In cleaning the electrodes, it would be simple to adopt a water-washing system, which is employed in ESPs in road tunnels. However, it would be necessary to treat the wastewater after such washing, and that would have failed to meet our development concept of integrating a sulfur oxide (SOx) scrubber with the ESP. Therefore, we decided to adopt an air-cleaning system.

Whenever we describe our development concept to experts in the marine industry, we are asked the following question: "How is the collected dust treated?" Figure 2 shows the appearance of the collected dust. PM collected by the ESP increases in volume as a result of coagulation. However, it is flocculent and the bulk density is low; it is friable, which makes disposal difficult. It could lead to inhalation of PM by crew members, which could pose a health hazard.

Figure 2. Appearance of collected dust

To overcome this problem, we developed a system for compressing the collected dust, thereby decreasing its volume. Figure 3 shows the appearance of the dust after compression. To achieve this compression in a cost-effective manner, we adopted a mechanism that is used for beverages sold in cups in automatic vending machines. That mechanism is effective for transferring powdered materials. Using that approach, we were able to achieve a 70% reduction in the volume of collected dust.

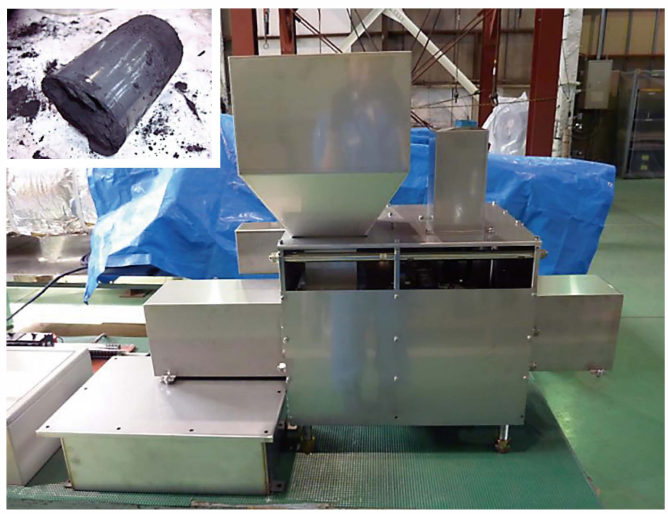

Figure 3. Dust compressor and pellet-like form of compacted treated dust (top left)

With our system, dust is automatically discharged into a container, such as a drum, installed beneath the dust compressor. It is then necessary only for crew members to replace the recovery container periodically. The final collected dust is in the form of a firm, compacted pellet. As a result, the risk of inhalation of PM by crew members is significantly decreased.

The major component of the collected dust is carbon, and so it can be employed as a fuel or coal ash in coal thermal power plants. We consider this potential use an advantage of the dry ESP for marine engines.

Monitoring control system

In the previous section, we indicated how the ESP needs to undergo periodic maintenance. One feasible operating method for the ESP is to preserve the discharge voltage (or current) of the ESP power supply at a constant level and set a timed operation for an automatic maintenance mechanism. However, such an approach would not allow monitoring of the ESP's performance, i.e., its dust-collection efficiency. This would make it difficult to minimize operation costs (including power consumption); it would also make it difficult to determine the pollution load of the wastewater from the wet-type SOx scrubber installed in the final stage of the exhaust gas cleaning system (EGCS). Accordingly, we had to consider how we should control such component devices as the ESP power supply and automatic maintenance mechanism.

We installed a means of measuring the concentration of dust (PM) upstream and downstream of the ESP to assess its performance. In this way, we were able to control operations to achieve our target performance levels. We were also able to assess exhaust gas properties (fluctuation in soot concentration owing to variations in engine load factor) and the performance of the ESP. This approach minimizes operation costs through optimized control based on fluctuations in the dust load on the ESP. In addition, it becomes possible to determine the pollution load of wastewater from the wet-type SOx scrubber in the final stage of the EGCS.

As an alternative to the dust-measurement system upstream of the ESP, inputting information related to the mechanism (such as engine load into the EGCS control device) may be assumed to reduce equipment costs. Here, however, it is necessary to determine in advance whether problems might arise with respect to information management of ship operations.

Verification of ESP supervisory control system

We conducted a verification test of the ESP supervisory control system for marine engines using a hole-type ESP prototype and laser dust monitor prototype. Figure 4 shows the structure of the equipment used in the verification test.

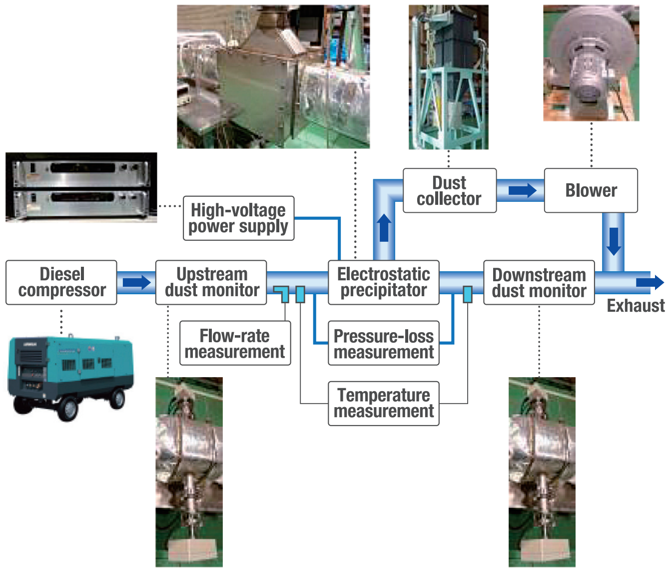

Figure 4. Structure of equipment used for verification test of the ESP supervisory control system for marine engines

The test conditions were as follows. The internal temperature of the ESP was set within a range of 260°–270°C; the treatment flow rate was set to approximately 9 m/s. The dust-collection efficiency was assessed with the ESP under continuous operation for 24 hours. The ESP was operated under constant-voltage control: the applied voltage remained at 7 kV throughout. Automatic maintenance was set at once an hour.

Figure 5 shows the verification test result: the target was dust-collection efficiency of ≥50%. The dust monitor operated as anticipated and was able to monitor the performance (dust-collection efficiency) of the ESP based on the measurement data from the two devices in real time.

We determined the dust-collection efficiency using the following equation:

$$T_{eff} = \{1-(\log T_d-\log T_0)/(\log T_u-\log T_0)\} \times 100$$

where T_{eff} signifies dust-collection efficiency, T_0 transmission rate (downstream), T_d transmission rate (at time of calibration), and T_u transmission rate (upstream).

Although the dust-collection efficiency tended to decrease owing to accumulation of PM within the ESP, the efficiency was restored by the automatic maintenance. This demonstrated that the dust-collection efficiency could be maintained at 55%–60% over 24 hours.

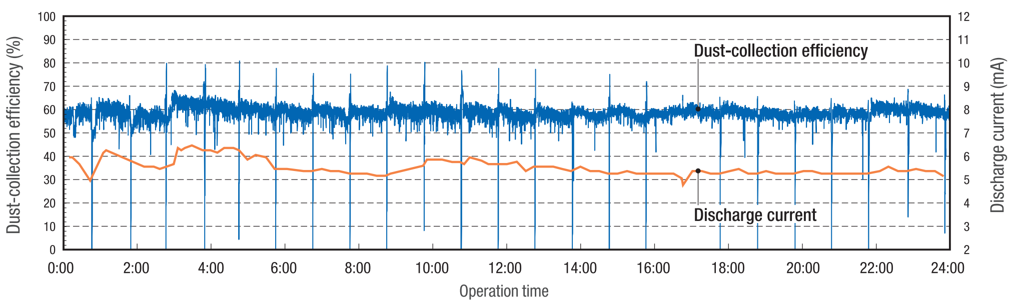

Figure 5. Result of verification test of ESP supervisory control system for marine engines

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